

Remote sensing of magnetic fields around the Earth

Outside of the laboratory (Patton et al., 2012), geomagnetic fields have never been remotely sensed. This is in sharp contrast to stellar magnetic fields (Zirker, 2009). If geomagnetic fields could be measured remotely at the nanoTesla (nT) level or better, our understanding of the processes that produce geomagnetic fields would advance markedly. Like the gravitational field, the magnetic field is one of very few important measured fields that are determined almost exclusively in-situ. The inability to remotely sense these fields has hindered their utility. A Remote Atmospheric Magnetism Workshop (<http://core2.gsfc.nasa.gov/research/purucker/rema.html>), sponsored by the Office of Naval Research, was held in Washington DC on 25-26 April, and highlighted advances in this frontier area, focusing on lab and field-based studies.

Remote sensing topics that were covered included: 1) magnetic fields in the mesosphere (Higbie et al., 2011) sensed using Na excited with GuideStar technology, and 2) magnetic fields in the lower atmosphere sensed by lasers that can be tuned to provide backward lasing or radar signatures.

In overviews by Potashnik, Patton, and Budker, the requirements for atomic magnetometry were elaborated. The remainder of the meeting was devoted to presentations of ongoing and planned studies devoted to achieving that goal. In the next paragraphs I highlight some of the most tantalizing possibilities.

The mesosphere, the boundary between the atmosphere and ionosphere, is one of the most poorly observed regions in all of space because access is solely by rocket or remote sensing. As discussed by Kane, a proof of concept test for remote sensing in the mesosphere is under development for the Kuiper telescope near Tucson. The laser will be pulsed near the Larmor frequency where measurements of the magnetic field will be attempted using Na in meteoric layers (Withers et al., 2008). The magnetic sensitivity goes as $1/(t \cdot \sqrt{N})$ where N is the number of returned photons detected and t is the coherence lifetime. Models suggest that nT level measurements may be possible.

In the atmosphere, backward lasing would allow for the efficient sampling of remote regions as the beam returns, and has been successfully used on the meter scale in the laboratory with lasers (Dogariu et al., 2011). In addition to lasers, this technique might be implemented with radar (Dogariu and Miles, 2011) and R. Miles, in his talk, presented a thought experiment on how the radar approach, and a variety of pumping concepts, might be used with Xe¹²⁹ to achieve resonance behavior that could be interrogated for magnetic intensity.

Many processes in the near-Earth environment produce magnetic fields. The measurement of those fields in frontier regions offers the promise of discovery and further insight into those processes.

References:

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